PCT

WORLD INTELLECTUAL PROPERTY ORGANIZATION
International Bureau

INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(51) International Patent Classification 4 : A47J 39/00, A23L 1/01

A1

(11) International Publication Number: WO 89/ 00393

(43) International Publication Date: 26 January 1989 (26.01.89)

(21) International Application Number: PCT/US88/01485

(22) International Filing Date: 6 May 1988 (06.05.88)

(31) Priority Application Number: 072,893

(32) Priority Date: 14 July 1987 (14.07.87)

(33) Priority Country: US

(71) Applicant: BELLAS, INC. [US/US]; 1846 Charter Lane, Lancaster, PA 17601 (US).

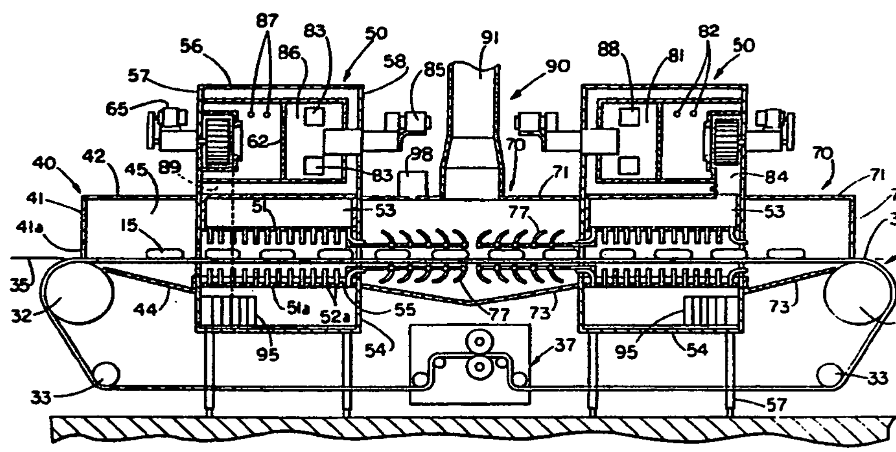
(72) Inventors: BELLAS, Benjamin, John ; 23411 Via Guadix, Mission Viejo, CA 92691 (US). O'CONNELL, Peter, Michael ; 231 Tree Street, Philadelphia, PA 19148 (US).

(74) Agents: SNYDER, Ronald, J. et al.; Frost & Jacobs, 2500 Central Trust Center, Cincinnati, OH 45202 (US).

(81) Designated States: AT (European patent), AU, BE (European patent), CH (European patent), DE (European patent), DK, FR (European patent), GB (European patent), IT (European patent), JP, KR, LU (European patent), NL (European patent), NO, SE (European patent), SU.

**Published**
*With international search report.*

(54) Title: METHOD AND APPARATUS FOR PULSE HEATING AND COOKING FOOD PRODUCTS




**(57) Abstract**

There is provided a continuous feed oven (10) for heating and cooking a food product (15), and including a conveyor (30) for continuously moving product (15) through the oven along a substantially longitudinal path (35). A plurality of spaced high velocity impingement zones (50) are located along the longitudinal path (35) of the oven, with each such zone having a plurality of spaced air jets (52, 52a) for impinging gases at predetermined elevated temperatures, humidity and at predetermined high velocities against the outer surfaces of products being conveyed along such conveyor (31). A relaxation zone (70) is integrally interposed between each adjacent impingement zone (50), with the relaxation zone (70) effectively isolating adjacent impingement zones (50) from one another and providing an equilibration space having a temperature substantially equal to the predetermined elevated temperatures of the preceding impingement zone (50). The velocity of movement of gases within the relaxation zone (70) is substantially lower than in adjacent impingement zones (50), whereby a product (15) passes through a series of alternating high velocity impingement (50) and low velocity relaxation zones (70) such that an effective thermal pulsing heat application is provided to the product (15) at predetermined elevated temperatures substantially above the desired finished temperature of the product (15).

*FOR THE PURPOSES OF INFORMATION ONLY*

Codes used to identify States party to the PCT on the front pages of pamphlets publishing international applications under the PCT.

| | | | | | |
|---|---|---|---|---|---|
| AT | Austria | FR | France | ML | Mali |
| AU | Australia | GA | Gabon | MR | Mauritania |
| BB | Barbados | GB | United Kingdom | MW | Malawi |
| BE | Belgium | HU | Hungary | NL | Netherlands |
| BG | Bulgaria | IT | Italy | NO | Norway |
| BJ | Benin | JP | Japan | RO | Romania |
| BR | Brazil | KP | Democratic People's Republic of Korea | SD | Sudan |
| CF | Central African Republic | KR | Republic of Korea | SE | Sweden |
| CG | Congo | LI | Liechtenstein | SN | Senegal |
| CH | Switzerland | LK | Sri Lanka | SU | Soviet Union |
| CM | Cameroon | LU | Luxembourg | TD | Chad |
| DE | Germany, Federal Republic of | MC | Monaco | TG | Togo |
| DK | Denmark | MG | Madagascar | US | United States of America |
| FI | Finland | | | | |

# METHOD AND APPARATUS FOR PULSE HEATING AND COOKING FOOD PRODUCTS

## I. Technical Field.

This invention relates to an improved method and apparatus for pulse heating and cooking of various food products, and, more particularly, to a method and apparatus for pulse heating and cooking which features the predetermined alternation of thermal periods, wherein processing gases are impinged at high velocities and at a predetermined humidities and elevated temperatures against the outer surfaces of a food product, with relaxation periods wherein a predetermined elevated temperature is maintained and the velocity of the gases is substantially reduced to enable equilibration of the temperature gradients within the food product.

## II. Background Art.

Conventionally, food products have been heated and cooked in one of two ways: (1) either they were processed in a high-temperature apparatus whose interior temperature was well above the temperature at which food typically undergoes cooking (i.e. cooking typically occurs between about 140° and about 200° F) for relatively short periods of time, or (2) were processed in a low-temperature cooking apparatus (e.g. about 200° F) for long periods of time. The deleterious effects of

high-temperature cooking is widely recognized, as such cooking is destructive to nutrients, vitamins and valuable soluble constituents of the food, and tends to rob the food of taste and flavor. With conventional low-temperature cooking, the oven temperature is maintained at or only slightly higher than the cooking temperature of the food, and nutrients, valuable constituents, taste and flavor are better preserved. However, because the results in heat differential between the food to be cooked and the interior temperature of the apparatus is relatively small, the cooking time in a low-temperature apparatus is often prohibitively extended.

U.S. Patent 4,374,319, which issued to Raul Guibert on February 15, 1983, discusses an oven device which allegedly can accomplish low-temperature cooking of food more efficiently and more rapidly than conventional low-temperature ovens. In particular, in the Guibert '319 oven, air is circulated within a box-like housing by a suction fan which pulls the air through the oven and past the food held within and past electric resistance heater elements in a circular pattern. There are specifically two heating coils which can be thermostatically controlled during operation. An electronic control circuit operates to switch both the fan and the heater elements on and off periodically so that there are periods of hot air flow past the food, and distinct intervals wherein there is no air flowing in the oven and the temperature is reduced. The resulting pulsatory heat wave produced in the oven thereby includes hot air pulses whose temperature is substantially above the cooking temperature of the food, and distinct no-flow periods where the temperature of the outer surface of the food is allowed to cool down so that cooking can be carried out

at a low-temperature, and so that no part of the food body is ever heated above its low-temperature cooking level. Guibert also suggests that the no-flow periods could be accomplished by a baffle arrangement within the oven which could intermittantly deflect the air flow to prevent it from circulating past the food item. Similar pulsatory heat wave units are shown and described in other U.S. patents which issued to R. Guibert, including U.S. Patents 4,381,442; 4,381,443; and 4,455,478.

A hot air oven for heating food cartridges is shown in U.S. Patent 4,132,216 which issued to R. Guibert on January 2, 1979. In particular, the '216 patent shows a hot air oven for heating a predetermined number of food-loaded cartridges designed to rapidly raise the temperature of pre-cooked food or other products characterized by low thermal conductivity; and, thereafter, to maintain the product at a predetermined heated temperature without overcooking. The food-loaded cartridges are arranged on a rotating turntable and are caused to be cyclicly rotated through a hot zone and an extra-hot zone. The extra-hot zone has a temperture well above the serving temperature of the food product so that the a marked temperature differential exists between the heated air and the food, even as the food within the cartridges approaches serving temperature. An arcuate shield formed within the device acts to restrict the passage of heated air through holes formed in a carton surrounding the food-loaded cartridges when in the hot zone, preventing air from flowing around such cartridges. On the contrary, a propeller blows heated air through the holes of the cartons surrounding the cartridges when in the extra-hot zone to heat the food in the trays. The flow of heated air in the extra-hot zone is designed to accelerate the rate of heat-up of the food cartridges

such that the time/temperature curve remains relatively steep throughout the entire heating procedure. A curtain of heated air surrounds the circular apparatus to provide access to the heated food trays while substantially containing the heat within the device. A similar two-zone hot air rotating oven is also shown in U.S. Patent 4,307,286 which also issued to R. Guibert.

A combination microwave and impingement heating apparatus is shown in U.S. Patent 4,409,453, which issued to D. Smith on October 11, 1983. In particular, the Smith '453 device includes a microwave oven which has been adapted to include a system of air jets above and below a food product held therewithin, with such air jets designed to accomplish surface browning and relatively uniform heating of the surfaces of odd shaped food products. In particular, relative movement between the food product and the air being discharged allegedly produces a "sweeping" or "wiping" action to provide uniform heating. Microwave energy is employed to heat the interior portions of the food product. The Smith patent also suggests the use of the combination hot air jet/microwave apparatus in a continuous manner wherein the means for supporting the food product comprises a continuous wire mesh conveyor. Again, the columnated jet of heated air is described as impinging the surface of the food product in a wiping action to penetrate the boundary layer of air surrounding the food product which would normally form an insulation barrier. The rate of heat transfer from the heated jets of air to the food products is set forth as being greater than the rate of migration of moisture from the center of the food product to the exterior surface thereof. In this way, browning of the food product can be accomplished without excessive removal of moisture therefrom.

Similar cooking apparatuses are shown in several other U.S. patents issued to D. Smith, including U.S. Patent 4,154,861; 4,338,911; 4,289,792; and 3,884,213.

Additionally, continuous feed air jet ovens have been employed in the industry wherein a product to be cooked is initially heated or tempered in a first zone to slowly raise the temperature of the product at a moderate cooking temperature range. Once heated to a moderate cooking temperature, browning of the outer surface of the food product is achieved by impinging the product with high velocity air heated well above (e.g. between about 800° and 1000° F) the cooking temperature of the food product. After browning has been completed by the high velocity heated air, the heat applied to the product during the initial tempering and the high velocity browning phases is allowed to migrate to the center of the product in an equilibration zone heated to a moderate cooking temperature. In this way, initial tempering, rapid browning, and equilibration are undertaken in distinct phases of varying temperatures and air velocities.

Despite all of this previous work undertaken, there remain problems in efficiency and quality which have heretofore not been addressed. In particular, in the pulsatory heat wave apparatuses taught in the Guibert patents, generally only a limited number of food products or food product containers could be processed at any given time. Additionally, the versatility of the systems was severely limited in that processing conditions, such as the humidity level of heated air circulated therewithin, could not easily be varied during any particular heating or cooking cycle. These prior apparatuses required the inefficient switching of fans,

heater elements and/or damper structures to divert heat and/or air flow during their "no-flow" processing cycles. Similarly, with the Guibert rotary-type heating and cooking devices, versatility of the system was extremely limited as only a relatively small number of food items could be processed at any given time, and a relatively extended cooking time was necessary because at least half of the processing was accomplished at slow-cooking temperatures.

While the Smith references contemplated use of their combination microwave/impingement heating apparatus in a continuous mode, cooking with microwave energy often fails to properly render blood, fat and other undesirable substances from particular food products, and the constant hot air impingement browning procedures can cause certain portions of the food product to be overcooked or burned. Likewise, heretofore, the continuous feed air-jet type ovens have employed tempering and equilibration zones having relatively low temperatures maintained generally within the low-temperature cooking range of a particular food product. Therefore, while these known processes and apparatuses could achieve various low-temperature food product qualities, they each suffered from various aspects of the inherent inefficiences of low-temperature cooking.

## III. <u>Disclosure of the Invention</u>.

It is an object of this invention to provide a more efficient method and apparatus for heating and cooking food products.

It is another object of the present invention to provide a more economical and relatively rapid method and

apparatus for heating and cooking food products which consistently achieves the desirable qualities and characteristics of conventional low-temperature cooking.

It is yet another object of the present invention to provide an improved method and apparatus for heating and cooking food products which can be easily adapted to a variety of continuous commercial applications.

In accordance with one aspect of the present invention, there is provided a continuous feed oven for heating and cooking a food product, including a conveyor for continuously moving product through the oven along a substantially longitudinal path. A plurality of spaced impingement zones are located along the longitudinal path of the oven, with each such zone having a plurality of spaced air jets for impinging gases at predetermined elevated temperatures and humidities and at predetermined high velocities against the outer surfaces of product being conveyed along such conveyor. A relaxation zone is integrally interposed between each adjacent impingement zone, with the relaxation zone effectively isolating adjacent impingement zones from one another and providing an equilibration space having a temperature substantially equal to the predetermined elevated temperatures of the preceding impingement zone. The velocity of movement of gases within the relaxation zone is substantially lower than in adjacent impingement zones, whereby product passes through a series of alternating impingement and relaxation zones such that an effective thermal pulsing heat application is provided to the product and the predetermined elevated temperatures throughout the oven are constantly maintained substantially above the desired finished temperature of the product.

## IV. Brief Description of the Drawings

While the specification concludes with claims particularly pointing out and distinctly claiming the present invention, it is believed that the same will be better understood from the following description taken in conjunction with the accompanying drawings in which:

FIG. 1 is a flow chart generally depicting a heating and/or cooking procedure in accordance with the subject invention;

FIG. 2 is a top plan view of a continuous feed oven apparatus made in accordance with the subject invention;

FIG. 3 is a vertical cross-sectional view of the continuous feed oven of FIG. 2, taken along line 3-3 thereof;

FIG. 4 is a vertical cross-sectional view of the continuous feed oven of FIG. 2, taken along line 4-4 thereof;

FIG. 5 is a partial perspective view of an impingement zone of the subject oven, illustrating details of a preferred embodiment; and

FIG. 6 is a partial cross-sectional view of a preferred embodiment of a continuous feed oven including vertically adjustable impingement tubes and baffles.

## V. Detailed Description of the Invention.

Turning now to the drawings in detail, wherein like numerals indicate the same elements throughout the views,

FIG. 1 illustrates a flow chart embodying the general process of the subject invention, while FIGS. 2 through 6 include details of a preferred continous feed oven 10 for heating and cooking food product made in accordance with the subject invention and implementing the process illustrated in FIG. 1.

In particular, FIG. 2 is a top plan view of a continuous feed oven 10 including, generally, an outer housing 20 having a plurality of zones integrally connected to establish a substantially unitary structure. Oven 10 is shown as including five zones arranged in seriatim to heat and/or cook food product 15 which is continuously moved from left to right on a conveyor system 30. Conveyor 30 preferably comprises an endless belt 31 which is preferably formed of a porous, metallic construction such as stainless steel or the like, but may also be modified for use in conjunction with microwave energy, as will be discussed in further detail below. The specific structural means for conveying product 15 through continuous feed oven 10 is not critical to the subject invention and can be accomplished by any of a variety of conveying systems known in the art.

Conveyor system 30 is illustrated in FIG. 3 as including a pair of oppositely disposed end rolls 32 about which endless belt 31 rotates, as well as a pair of oppositely disposed idler or tension rolls 33. Product 15 to be heated and/or cooked is thereby supported on belt 31 and conveyed along the longitudinal axis or pathway 35 through oven 10 for processing. Additional support rollers (not shown) can also be appropriately spaced throughout the length of conveyor system 30 for additional belt support. As will be appreciated from the discussion below, belt 31 is preferably made of a porous

nature [illegible] facilitate and permit re[illegible]ively unencumbered flow of processing gases within the system. In this regard, it may also be preferred to provide a washing mechanism (e.g. as shown generally at 37 of Figure 3) through which belt 31 must pass as it returns to the front end of oven 10.

Product 15 placed upon belt 31 first enters tempering zone 40 within which product 15 is subjected to processing gases such as heated air and, possibly, steam or other predetermined humidity, which has been heated to a predetermined elevated temperature T which is substantially above the desired finished temperature or cooking temperature of product 15. As used herein, the terms "finished" or "cooking" temperature of a particular product shall connote the minimum internal temperature to which such product must be heated in order to be considered "cooked". For example, the cooking or finished temperature for chicken is about 170° F (about 76.6° C). This predetermined temperature T may, of course, vary between specific applications according to the type and size of product to be processed, the beginning temperature of such product (e.g. depending upon whether the product is frozen, at room temperature or otherwise), the longitudinal length of tempering zone 40, the belt speed of conveyor system 30, and the like. It should also be noted that particular parts of a product may have a higher temperature at the completion of the process, as some parts will be more remote or insulated from the heat source. Due to the equilibration sequences involved herein, however, any such temperature deviations will be limited.

Tempering zone 40 may include means (not shown) for providing such predetermined elevated temperature

therewithin, may receive heated processing gases from the adjacent impingement zone 50 (as discussed below), or may utilize a combination of both. Tempering zone 40 is made up of left side wall 41 which is provided with an opening or adjustable door structure 41a which optimally minimizes the height of such opening to accommodate belt 31 and product 15 supported thereon without interference. An adjustable door structure 41a is preferred to minimize the amount of heat loss from the system which might otherwise occur through an oversized opening.

Tempering zone 40 further comprises top wall 42, front wall 43, opposite rear wall 45, and an inclined bottom wall 44 which preferably forms a drip pan for drainage of grease and the like emanating from various products 15 being processed within zone 40. Preferably the wall structures forming tempering zone 40 and the balance of the multi-zoned housing 20 of oven 10 are formed of a double wall construction (which might also include insulation material) to retain heat and minimize heat loss from oven 10 during use.

Tempering zone 40 is integrally connected with a high velocity impingement zone 50 located adjacent tempering zone 40 in the longitudinal direction of travel of product 15 on conveyor system 30. Impingement zone 50 is designed to subject the tempered product to high velocity processing gases which are substantially uniformly impinged against the outer surfaces of product 15. Impingement zone 50 is illustrated as including top wall 56 and the downwardly depending alternating left side wall 57, front wall 59, right side wall 58 and rear wall 59. Attached to the upper outer portions of impingement zone 50 is an upper blower motor 60 and a corresponding lower blower motor 65. Upper blower motor

60 is mounted for fluid communication with upper plenum 53 which is connected about its lower portions to an upper manifold plate 51 having a plurality of spaced air jet tubes 52 depending downwardly therefrom. Similarly, lower blower motor 65 is placed in fluid communication with a lower plenum 54 having a lower manifold plate 51a with a corresponding plurality of air jet tubes 52a attached thereto. As seen best in Figures 3 and 4, blower motors 60 and 65 are each mounted oppositely from a corresponding burner (80 and 85, respectively). It is contemplated that standard pre-mix burner systems (such as commonly available from Maxon Corporation of Muncie, Indiana) can be used for burners 80 and 85, and the burner flames are directed inwardly within heating chambers 81 and 86, respectively, toward a baffle plate (e.g. 62) mounted centrally within each heating chamber. While it is contemplated that it may not always be necessary or desirable to include this baffle plate 62, such is generally preferred to protect the oppositely disposed blower fans and help establish a turbulence within the heating chamber. The processing air or gases will be pulled by the blower fans through circulation inlets 83 and 88, respectively, through heating chambers 81 and 86 and then dispersed to upper and lower plenums 53 and 54, respectively. Recirculated processing gases enter the heating chambers 81 and 86 through inlets 83 and 88, respectively, and are heated by the flames of the burners therewithin. The heated air then flows around the central baffle (e.g. 62) and is forced into the upper and lower plenums via supply conduits 84 and 89, respectively. Humidity may also be added to the heated processing gases, such as by steam injectors 82 and 87 located adjacent baffle plate 62 just outside heating chambers 81 and 86, respectively. The location of such steam injectors could alternatively be anywhere within

the recirculation pattern, such as within heating chambers 81 and 86, adjacent inlets 83 and 88, respectively, or within return air ducts 61 and 64, respectively.

Heated processing gases (e.g. humidified air) are thereby forced by upper blower motor 60 into upper plenum 53 and through manifold plate 51 and its depending jet tubes 52 under predetermined pressure to impinge product 15 at a predetermined high velocity $V_1$. Similarly, lower blower motor 65 forces heated processing gases into lower plenum 54 and through its corresponding manifold plate 51a and jet tubes 52a against the lower outer surfaces of product 15. Impingement zone 50 is preferably substantially larger than the adjacent tempering zone 40 in order to accommodate the high velocity impingement apparatus as set forth above, as well as to provide appropriate recirculation structure (e.g. return air ducts 61 and 64) to enable such impinged processing gases to be appropriately recirculated to the respective blower motors.

In particular, it is preferred that processing gases are recirculated both within impingement zone 50 and through the adjacent tempering zone 40 and, as will be described below, the adjacent relaxation zone 70 to facilitate the maintenance of the predetermined elevated temperatures within the system. It is preferred that the manifold plates 51 and 51a and attached jet tubes 52 and 52a are to be mounted within the respective upper and lower plenums 53 and 54 for easy removal and replacement for cleaning, maintenance, repair and the like. While spacing of individual tubes within the respective manifold plates may be varied as desired, it is preferred that such jet tubes 52 be appropriately arranged and

spaced apart to provide substantially uniform impingement of product 15 regardless of its position on belt 31 as it passes through impingement zone 50. As seen best in Figure 4, the length of tubes 52 also provides space for processing gases to move toward the oppositely disposed return air ducts 64 and 69 of impingement zone 50 for recirculation to heating chambers 81 and 86 without substantially interfering with the impingement pattern of processing gases from tubes 52. The vertical spacing of tubes 52 and 52a from belt 31 will be discussed in greater detail below.

It is also contemplated that for particular product applications, certain of such jet tubes 52 and 52a might be blocked off to correspond with product peculiarities (e.g. whole turkeys having some very high spots and some relatively low spots) to enable a precisely predetermined pattern of impingement. For example, it might be preferred that resultant processing gases impinged on high spots of product 15 should be reduced to minimize potential overcooking of such high spots, while impingement in lower areas remains at full force. Plenums 53 and 54, respectively, preferably extend fully across the width of belt 31 of conveyor system 30 as well as along the length of thermal zone 50, as best seen in FIGS. 3 and 4. Return air ducts 61 and 64 are therefore preferably confined to the front and rear portions of impingement zone 50 laterally beyond the outer edges of the width of belt 31. It is also preferred to include a water moat 55 for receiving cool water to provide a continuous source of humidity to thermal zone 50, as well as to carry off suspended grease and other drippings from the product and to prevent grease fires or smoking therewithin during processing. Additionally, the water within such moat may pass across a weir (not shown) on one side thereof to

carry off suspended grease. Removal of such grease and drippings minimizes pollution or smoke which might otherwise result from grease burning on the lower manifold. As indicated by the flow path arrows of FIGS. 3 and 4, heated processing gases are impinged against product 15 from both above and below, after which such gases are recirculated to the blower motors and burners via return air ducts 61 and 64.

As seen in Figure 3, it is also preferred that some of the air jet tubes 52 and 52a nearest the adjacent tempering zone 40 or relaxation zones 70 are directed to supply heated processing gases to such adjacent zones. Because predetermined elevated temperatures substantially above the cooking temperature of product 15 are to be maintained throughout oven 10, it is not critical to confine the heated processing gases within a particular impingement zone 50, as such heated gases can help maintain the elevated temperatures in the adjacent zones by circulating therethrough.

Recirculated processing gases preferably pass through some kind of filtering system (e.g. mechanical type filters, such as shown at element 92 of FIG. 4) and subsequently past the burners or other heating elements associated with the blower motors. As described above, the heated gases are thereafter forced by such blower motors into respective upper and lower plenums to provide the predetermined high velocity impingement streams via tubes 52 and 52a. Impurities can thereby be removed from the gases by the filtering apparatus and by being consumed as they pass the burners. Mechanical filters 92 preferably comprise relatively standard reverse-vent type elements which force the recirculated gases to undergo severe directional changes as they return to the heating

chambers 81 and 86. Such abrupt directional variations cause suspended grease and impurities in the gases to be deposited on the filters, and such deposits can thereafter be collected for disposal, such as by a drip pan or collector (e.g. drip pan 93). Filters 92 are illustrated as preferably located within return air ducts 61 and 64, with the lower portion of ducts 61 and 64 including drip pans 93.

While the predetermined velocity of processing gas issuing from the upper and lower manifold plates 51 and 51a and tubes 52 and 52a can be varied as desired, it is contemplated that the preferred range of velocities for such impingement is between about 4000 and about 8,000 fpm, although velocities outside this range might be appropriate in particular applications. In this regard, independent control of the blower fans and burners can enable independent control of temperature, humidity and velocity of processing gases being impinged from above and below conveyor means 30 within a particular impingement zone 50. For example, greater penetration of heat into a particular product might be accomplished by using higher velocities and/or higher temperatures from either above or below conveyor means 30, whereby increased humidity would prevent drying and/or burning of the surface of the product by the more intense heating provided by increased velocity and/or temperature.

As illustrated, heated processing gases issue directly from upper heating chamber 81 into upper plenum 53 through supply conduit 84, while such gases are supplied to lower plenum 54 from heating chamber 86 via supply conduit 89. The exact location of blower motors 60 and 65, as well as their specific conduit, baffle and related connecting structures are not critical to the present invention, and can be accomplished by a variety

of ways known in the industry. It is, however, preferred to locate both heating chambers 81 and 86 above their corresponding impingement zone 50 to efficiently take advantage of the recirculation pattern established therewithin. In order to minimize impingement zone overheating problems, it has been found preferable to include return inlets 83 and 88 both on the upper and lower portions of heating chambers 81 and 86 to ensure that the hottest gases are pulled back into the heating chambers for continued circulation within the oven.

Integrally attached to the right side or downstream wall 58 of impingement zone 50 is the housing structure of relaxation zone 70. In particular, relaxation zone 70 is comprised of top wall 71, front wall 72, rear wall 75, and inclined bottom wall 73. It is preferred that an inclined bottom wall 73 be formed to again provide a convenient drip pan for grease and other drippings emanating from product 15 during processing. Moreover, in continuous systems designed to operate for long periods of time, it may also be desirable to provide a shallow water moat above wall 73 similar to water moat 55 described above. As in tempering zone 40, relaxation zone 70 features relatively low processing gas velocity (i.e. substantially lower than impingement velocity in adjacent impingement zone 50), and is maintained at a predetermined elevated temperature substantially equal to (i.e. within about 20° F or about 7° C) of the predetermined elevated temperatures of preceding impingement zone 50. If different temperatures of processing gases are being applied from above and below product 15 in an impingement zone 50, the predetermined elevated temperature would preferably be at least substantially equal to the lesser of those preceding impingement zone temperatures. Alternatively, the

elevated temperature within the relaxation zone might be substantially equal to the average of different adjacent impingement zone temperatures.

As will be seen, relaxation zone 70 serves the critical function of both isolating adjacent impingement zones and providing an equilibration zone wherein temperature gradients within product 15 can be equilibrated and reduced. Within relaxation zone 70, the relatively high surface temperature of product 15 resulting from the high velocity impingement of heated processing gases within the impingement zone 50 is given time to migrate inwardly into product 15. Because the elevated temperature of the preceding impingement zone 50 is substantially maintained within relaxation zone 70, heat applied during such previous impingement zone processing tends to move inwardly into the cooler central portions of product 15, as opposed to moving outwardly into the ambient gases within zone 70. In this way, more complete and even heating and cooking is provided in an efficient manner while minimizing heat loss from the system, and maximizing the uniform input of such heat to product 15 therewithin. As shown in Figure 3, relaxation zone 70 might also preferably be provided with a series of baffles 77 designed to direct flow of processing gases entering from adjacent impingement zones toward product 15. The resulting velocities of such baffled gases would be substantially lower than velocities in such adjacent impingement zones, and would serve to augment conduction of heat to such product. While baffles 77 are also illustrated below belt 31 in relaxation zone 70, it is contemplated that they could be omitted from the lower portion, as natural convection of heated air would likely provide adequate upward motion of processing gases toward product 15.

Relaxation zone 70 might also include additional heating means (e.g. such as a heating or microwave source 98 shown in the central relaxation zone 70) for ensuring the maintenance of the predetermined elevated temperature therewithin; however, it is contemplated that the circulation patterns within oven 10 will generally provide sufficient heat to the adjacent tempering and/or relaxation zones to maintain the temperature therewithin at the desired elevated temperatures. If, however, a particular desired elevated temperature is high enough (e.g. 450° or more), it may be necessary to supplement the heat within tempering zone 40 or relaxation zone 70 with additional thermal input.

As also shown in Figures 3 and 4, it is contemplated that an exhaust system 90 would also be necessary for safe and efficient operation of oven 10. Exhaust system 90 is shown only as an example of the many ways in which such could be accomplished, and includes an exhaust stack 91 centrally located in the upper portions of middle relaxation zone 70. Exhaust system 90 would include appropriate exhaust manifold structure (not shown) to draw process gases from the oven for removal. Exact locations and numbers of such exhaust systems should be designed to provide sufficient exhausting for safety and to further control gas flow patterns, temperatures, and the like within an oven system made in accordance herewith. For example, exhaust systems utilizing larger exhaust fans might cause impingement gases of several successive impingement zones to be drawn toward a single outlet, thereby influencing the gas flow pattern and exact elevated temperatures in an intermediate relaxation zone. Exhaust system placement could similarly be employed to facilitate effective isolation of adjacent

impingement zones by flow direction control.

While it is contemplated that a single impingement zone and a single subsequent relaxation zone may be sufficient in many applications to adequately heat and/or cook a particular product 15, it is preferred that in most applications a tempering zone 40 be utilized prior to impingement zone 50 to initiate the heating procedure and to facilitate a substantially uniform heating and cooking of the product through the process. It has also been found that the use of a plurality of alternating impingement zones and relaxation zones in seriatim enables more reliable achievement of superior browning and cooking of various food products such as chicken, turkey, other meats, fried foods, fish, and the like. In particular, vastly improved processed products are achieved by the resulting process of impinging gases at high velocity and at a predetermined elevated temperature against the outer surfaces of a food product; substantially reducing the velocity of the gases while maintaining the ambient temperature around the food product at approximately that same elevated temperature of the preceding high velocity impingement step for a predetermined period of time to enable equilibration of the temperature gradients within the food product; following such reduced velocity equilibration time period with another impingement of gases at high velocity and predetermined elevated temperatures against the outer surfaces thereof; and following such second high velocity impingement with another reduced velocity equilibration time period at approximately the same elevated temperature of such preceding high velocity impingement step to again enable equilibration of temperature gradients therewithin; and repeating such alternating steps as necessary to provide efficient and relatively

rapid pulse-type heating and cooking of the product at temperatures substantially above the desired finished or cooking temperature of the product.

It has been found that the interposition of relaxation zones as described above between adjacent high velocity impingement zones effectively isolates such adjacent impingement zones from one another and enables the inward migration of thermal energy which has been applied to the product surface by such high velocity impingement. This effective isolation of adjacent impingement zones additionally enables the application of relatively widely varying combinations of velocities, humidities and temperatures of processing gases within individual impingement zones, and such freedom to manipulate these variables augments the substantially limitless versatility and adaptability of ovens made according to the present invention. The resulting pulse-type application of thermal energy at predetermined elevated temperatures substantially above the desired finished or cooking temperature of a particular product enables the achievement of superior product texture, moisture content, and retention of valuable nutrients and flavor in the processed product at relatively rapid rates without overcooking or burning.

As shown in FIGS. 2 and 3, a typical continuous oven application would include a series of alternating impingement zones 50 and relaxation zones 70, and preferably would include a tempering zone 40 (essentially identical to a relaxation zone 70) prior to the first impingement zone 50. While the drawing figures specifically illustrate a pair of impingement zones 50 isolated by the respective relaxation zones 70 and tempering zone 40, it is further contemplated that it may

often [illegible] desirable to have as ma[illegible] as four or five or more impingement zones 50 similarly isolated by respective relaxation zones 70 for use with larger products such as chickens, turkeys, or the like. It may also be preferred that each such impingement zone and/or adjacent relaxation zone be independently controlled vis-a-vis the temperature, humidity and velocity of processing gases therewithin. Such independent control provides an improved oven having virtually unbounded versatility and adaptability in a wide range of processing applications.

It should also be noted that the pulse-type heating and cooking process of the subject invention could equally be adapted for use in a single cavity, non-continuous feed or batch-type apparatus. In particular, the steps of tempering, high velocity impingement, and relaxation would simply be performed sequentially within such single unit, such that periods of high velocity impingement would be effectively isolated from periods of low velocity tempering or equilibration, while maintaining a predetermined temperature therewithin which is substantially above the cooking temperature of the product.

As mentioned above, the alternating steps of the subject process may preferably be performed with differing levels of humidity and/or steam introduced into the system. In particular, the high velocity impingement steps might preferably be performed with processing gases including steam for particular applications to maintain a desired moisture level within the product during processing. Similarly, particular velocities of the processing gases might desirably be varied between successive impingement zone applications, or even between

impingement from upper and lower plenums of a single impingement zone. It can, therefore, be seen that the resulting oven system and process of the subject invention is quite versatile and can be adapted to practically any product cooking and/or heating application. In this regard, it is further contemplated that the heating and cooking steps involved herein could also be augmented by the implementation of microwave energy during any of the particular steps set forth herein. For example, the continuous food oven 10 of FIGS. 2 and 3 might be modified to include a source of microwave energy (e.g. shown at 98 of FIGS. 2 and 3) to augment the application of heat to product 15 within equilibration zone 40. Likewise, such microwave energy could also be provided in any of the subsequent impingement zones 50 and/or relaxation zones 70, as desired.

Figure 5 illustrates a preferred manner of arranging supply conduit 89 to provide communication between heating chamber 86 and lower plenum 54 (it should be noted that conveyor system 30 has not been included in this view). In particular, impingement zone 50 is shown as including a front wall 59 having a pair of oppositely hinged door-like members 59a and 59b. It is contemplated that members 59a and 59b would preferably provide substantial and easy access to the interior of impingement zone 50 for maintenance, inspection, cleaning and the like. In this regard, it is preferred to route supply conduit 89 in door member 59b between lower heating chamber 86 and lower plenum 54 to similarly facilitate access thereto. Other ways of hingedly or removably mounting supply conduit 89 and/or front wall 59 could also be employed to provide access to conduit 89 and the interior portion of impingement zone 50.

Member 59b is shown as being formed with an arcuate conduit portion 59c and a removable panel 59d which serves to define conduit 89 therewithin. When in closed position (as shown in Fig. 4), conduit 89 connects the output channel 68 adjacent lower blower fan 67 with an input manifold 69 of lower plenum 54. As further illustrated in Figures 3 and 4, it is preferred to include turning vanes 95 within lower plenum 54 to uniformly distribute the heated processing gases within plenum 54 to ensure more uniform impingement via tubes 52. Turning vanes 95 can comprise one or more shaped fins or baffles designed to evenly direct incoming flow of processing gases within lower plenum 54. Additionally, as shown best in Figure 2, it is preferred to alternate which side of oven 10 on which conduit 89 is located for successive impingement zones 50 to more evenly distribute impingement flow from the respective lower plenums of such zones.

The vertical spacing from the distal ends of tubes 52 is preferably adjustable relative conveyor 30 and, particularly, product 15 on conveyor 30, to enable further control of processing gas velocities and impingement patterns on such product. Such vertical adjustability can most easily be provided by designing plenum 53 to be vertically adjustable relative belt 31. Any arrangement which would enable vertical adjustment between those parts, however, could be employed. It is contemplated that to enable such movement of plenum 53, either the entire upper portion of impingement zone 50 might be vertically adjustable relative belt 31 and the lower portions of zone 50, or, alternatively, a sliding fit between supply conduit 84 and the movable plenum 53 could be provided.

The vertical spacing between the upper distal ends of lower tubes 52a is preferably predetermined and

non-adjustable to ensure an impingement pattern against belt 31 and/or product 15 which provides for downward return flow of such gases without substantially interferring with the upward impingement pattern. While lower plenum 54 of impingement zone 50 could be made vertically adjustable, as described with respect to upper plenum 53 above, it is preferred to maintain tubes 52a at a predetermined distance below belt 31 and product 15 to enable gas flow as illustrated in FIG. 4. As seen, processing gases issuing from tubes 52a spread outwardly in a substantially conical manner to impinge product 15. Proper spacing of tubes 52a from one another and from belt 31 provides a substantially "dead" space through which gases can recirculate downwardly and laterally to be returned to heating chamber 86, as described herein. Such downward movement, in conjunction with the abrupt change in direction of such gases above the water in moat 55, facilitates removal of suspended grease and similar impurities from the processing gases prior to recirculation to the heating chambers. Such impurities tend to be deposited in the water moat for removal. In combination with other filtering systems (e.g. mechanical filters 92 described above), ovens made in accordance herewith can run continuously much cleaner and safer over extended periods of time without requiring major cleaning. Continuous, uninterrupted operation of ovens over extended periods of time (i.e. substantially constant operation) can, therefore, be realized by incorporation of the various unique features of the subject invention.

As indicated above, baffles 77 may also preferably be provided within relaxation zone 70 to direct the flow of processing gases toward product 15. Where the tubes (e.g. 52 and 52a) of adjacent impingement zones 50 are

vertically adjustable, it is further contemplated that baffles 77 can be correspondingly adjustable therewith. As best seen in FIG. 6, it is preferred that baffles 77 be rotatably fixed at their upper end, such as by pins 78, and linked by adjustment arm 79 at their distal ends to corresponding adjustable plenums 53 and 54. As indicated by the phantom lines of FIG. 6, as plenum 53 is vertically adjusted, baffles 77 would thereby be correspondingly adjusted to properly and optimally direct processing gases toward belt 31 and product 15 carried thereon. It should be noted that the exact manner of providing corresponding adjustment of baffles 77 with adjacent impingement zone tubes is not critical, and the adjustment arm assembly is included only as an example of a preferred structure.

As described above, the predetermined elevated temperatures utilized within an oven are expected to be variable between particular applications, and to be determined based on a number of variables related to the product and desired heating and/or cooking characteristics of the particular process contemplated. Conventional low-temperature cooking of products is often accomplished at a temperature of approximately 200° F (93° C) or less.

On the other hand, browning of various food products and the like is often accomplished in a temperature range of between about 800° F (427° C) and about 1000° F (538° C). High-temperature cooking is often undertaken in a temperature range of between about 450° F (232° C) to about 600° F (315° C). It has been found that the unique pulse-type method of heating and cooking food products as set forth in the subject invention disclosure can achieve superior heating and cooking characteristics in various

products utilizing the substantially constant processing temperature (predetermined elevated temperature T) in a range of between about 250° F (121° C) to 600° F (315° C). Consequently, the process of the subject invention can achieve superior results in a much more economical manner than heretofore available. For example, it has been found that whole chickens can be cooked and properly browned in an oven made in accordance herewith in as little as 32 minutes utilizing processing gases in the oven in a temperature range of between about 300° and 350° F (between about 149° C and 176° C). In a conventional convection-type oven generally used for this purpose in the industry, about two hours is nominal cooking time. It has also been found that the method and apparatus of the subject invention provides processed food products having superior flavor, texture and moistness characteristics while minimizing product yield losses which normally occur during cooking. An additional advantage of the subject invention can be seen in a continuous feed oven application, wherein the individual impingement zones, relaxation zones, and tempering zones can be manufactured in modular form so that systems can be mass-produced and easily combined in accordance with requirements of the user.

Various modifications of the described invention will be apparent to those skilled in the art. Examples of several of such variations have been mentioned and discussed above. Further adaptions could be made in order to customize a particular system for a specific use. For example, relaxation zones 70 could be equipped with manifold plates and jet tubes as described with regard to impingement zones 50, for application of low velocity processing gases to the products. Such modification is not particularly preferred in that it

would substantially increase the cost of the individual zones of the resulting continuous feed oven; however it might be desirable in situations where, for example, it is important to continually impinge the surface of the product with moisture-laden air or in order to create a self-basting action of the product throughout the process. In other applications, the initial equilibration zone (i.e. tempering zone 40) might be omitted, wherein product would pass directy into first impingement zone 70. Accordingly, the scope of the present invention should be considered in terms of the following claims and is understood not to be limited to the details of structure and operation described and shown the specification and drawings.

WHAT IS CLAIMED IS:

1. A continuous feed oven for heating and cooking food product, said oven comprising:

(a) a conveyor means for continuously moving product through said oven along a substantially longitudinal path;

(b) a plurality of spaced impingement zones located along said longitudinal path, said impingement zones each comprising a plurality of spaced jet tubes for impinging gases at predetermined humidity and elevated temperatures and at predetermined high velocities against the outer surfaces of product being conveyed on said conveyor means; and

(c) a relaxation zone integrally interposed between adjacent impingement zones, said relaxation zone effectively isolating adjacent impingement zones from one another and providing an equilibration space having a temperature therewithin substantially equal to the predetermined elevated temperatures of the preceding impingement zone, and wherein the velocity of movement of said gases is substantially lower than in said adjacent impingement zones, whereby product passes through a series of alternating impingement and relaxation zones such that an effective thermal pulsing heat application is provided to the product, and the predetermined elevated temperatures throughout the oven are constantly maintained substantially above the desired finished temperature of the product.

2. The continous feed oven of claim 1, wherein the predetermined humidity, elevated temperatures, and high

velocities of said impinging gases within a particular impingement zone can be controlled independently of other impingement zones of the oven.

3. The continuous feed oven of claim 1, wherein said spaced jet tubes of said impingement zones are located both above and below said conveyor means for simultaneously impinging the product on said conveyor means from both above and below.

4. The continuous feed oven of claim 3, wherein the velocities of gases being impinged from above and below said conveyor means within a particular impingement zone can be controlled independently of one another.

5. The continuous feed oven of claim 1, wherein a relaxation zone is integrally associated at both the front and rear longitudinal ends of each impingement zone.

6. The continuous feed oven of claim 1, wherein said oven further comprises microwave equipment to augment heating and cooking of the product within at least one of the interconnected zones thereof.

7. The continuous feed oven of claim 6, wherein the microwave augmentation is limited to one or more of said relaxation zones.

8. The continous feed oven of claim 1, wherein said predetermined elevated temperatures are maintained within a range of between 250° F and about 600° F, and wherein the connection of said impingement zones and said relaxation zones minimizes temperature gradients therewithin along substantially the entire longitudinal length

of said oven.

9. The continuous feed oven of claim 3, said oven further comprising conduit means for routing said impinging gases to said spaced jet tubes both above and below said conveyor means at least a portion of such conduit means being removably mounted to said oven to facilitate access thereto for repair and maintenance.

10. The continuous feed oven of claim 1, wherein said relaxation zone further comprises baffle means for directing processing gases entering from an adjacent impingement zone toward product being conveyed on said conveyor means.

11. The continuous feed oven of claim 1, wherein said jet tubes of at least one of said impingement zones are vertically adjustable relative said conveyor means.

12. A continuous feed oven for heating and cooking food product, said oven comprising:

(a) a conveyor means for continuously moving product through said oven along a substantially longitudinal path;

(b) a plurality of spaced impingement zones located along said longitudinal path, said impingement zones each comprising a plurality of spaced jet tubes for impinging gases at predetermined humidity and elevated temperatures and at predetermined high velocities against the outer surfaces of product being conveyed on said conveyor means;

(c) a control means for independently

controlling said predetermined humidity, elevated temperatures and high velocities of said impinging gases within the individual impingement zones; and

(d) a relaxation zone integrally interposed between adjacent impingement zones, said relaxation zone effectively isolating adjacent impingement zones from one another and providing an equilibration space having a temperature therewithin substantially equal to the predetermined elevated temperatures of the preceding impingement zone, and wherein the velocity of movement of said gases is substantially lower than in said adjacent impingement zones, whereby product passes through a series of alternating impingement and relaxation zones such that an effective thermal pulsing heat application is provided to the product, and the predetermined elevated temperatures throughout the oven are constantly maintained substantially above the desired finished temperature of the product.

13. The continuous feed oven of claim 12, wherein said spaced jet tubes of said impingement zones are located both above and below said conveyor means for simultaneously impinging the product on said conveyor means from both above and below.

14. The continuous feed oven of claim 13, wherein the velocities of gases being impinged from above and below said conveyor means within a particular impingement zone can be controlled independently of one another.

15. The continuous feed oven of claim 12, wherein a relaxation zone is integrally associated at both the front and rear longitudinal ends of each impingement zone.

16. The continuous feed oven of claim 12, wherein said oven further comprises microwave equipment to augment heating and cooking of the product within at least one of the interconnected zones thereof.

17. The continuous feed oven of claim 16, wherein the microwave augmentation is limited to one or more of said relaxation zones.

18. The continous feed oven of claim 12, wherein said predetermined elevated temperatures are maintained within a range of between 250° F and about 600° F, and wherein the connection of said impingement zones and said relaxation zones minimizes temperature gradients therewithin along substantially the entire longitudinal length of said oven.

19. The continuous feed oven of claim 13, said oven further comprising conduit means for routing said impinging gases to said spaced jet tubes both above and below said conveyor means.

20. The continuous feed oven of claim 12, wherein said relaxation zone further comprises baffle means for directing processing gases entering from an adjacent impingement zone toward product being conveyed on said conveyor means.

21. The continuous feed oven of claim 12, wherein said jet tubes of at least one of said impingement zones are vertically adjustable relative said conveyor means.

22. A continuous feed oven for heating and cooking food product, said oven comprising:

(a) a conveyor means for continuously moving product through said oven along a substantially longitudinal path;

(b) a plurality of spaced impingement zones located along said longitudinal path, said impingement zones each comprising a plurality of spaced jet tubes located both above and below said conveyor means for simultaneously impinging gases at predetermined humidity and elevated temperatures and at predetermined high velocities against the outer surfaces of product being conveyed on said conveyor means from both above and below;

(c) a control means for independently controlling said predetermined humidity, elevated temperatures and high velocities of said impinging gases within the individual impingement zones; and

(d) a relaxation zone integrally interposed between adjacent impingement zones, said control means further independently controlling said humidity, temperatures and velocities of gases issuing from said jet tubes above and below said conveyor means, respectively and said relaxation zone effectively isolating adjacent impingement zones from one another and providing an equilibration space having a temperature therewithin substantially equal to the predetermined elevated temperatures of the preceding impingement zone, and wherein the velocity of movement of said gases is substantially lower than in said adjacent impingement zones, whereby product passes through a series of alternating impingement and relaxation zones such that an effective thermal pulsing heat application is provided to

the product and the predetermined elevated temperatures throughout the oven are constantly maintained substantially above the desired finished temperature of the product.

23. The continuous feed oven of claim 22, wherein said oven further comprises microwave equipment to augment heating and cooking of the product within at least one of the interconnected zones thereof.

24. The continuous feed oven of claim 22, said oven further comprising conduit means for routing said impinging gases to said spaced jet tubes both above and below said conveyor means.

25. The continuous feed oven of claim 22, wherein said relaxation zone further comprises baffle means for directing processing gases entering from an adjacent impingement zone toward product being conveyed on said conveyor means.

26. The continuous feed oven of claim 22, wherein said jet tubes of at least one of said impingement zones are vertically adjustable relative said conveyor means.

27. A continuous feed oven for heating and cooking food product, said oven comprising:

(a) a conveyor means for continuously moving product through said oven along a substantially longitudinal path;

(b) a plurality of spaced impingement zones located along said longitudinal path, said impingement zones each comprising a plurality of spaced jet tubes

located both above and below said conveyor means for simultaneously impinging gases at predetermined humidity and elevated temperatures and at predetermined high velocities against the outer surfaces of product being conveyed on said conveyor means from both above and below;

(c) conduit means for routing said impinging gases to said spaced jet tubes, at least a portion of said conduit means being removably mounted to said oven to facilitate access thereto;

(d) a control means for independently controlling said predetermined humidity, elevated temperatures and high velocities of said impinging gases within the individual impingement zones; and

(e) a relaxation zone integrally interposed between adjacent impingement zones, said control means further independently controlling said humidity, temperatures and velocities of gases issuing from said jet tubes above and below said conveyor means, respectively; and said relaxation zone effectively isolating adjacent impingement zones from one another and providing an equilibration space having a temperature therewithin substantially equal to the predetermined elevated temperatures of the preceding impingement zone, and wherein the velocity of movement of said gases is substantially lower than in said adjacent impingement zones, whereby product passes through a series of alternating impingement and relaxation zones such that an effective thermal pulsing heat application is provided to the product and the predetermined elevated temperatures throughout the oven are constantly maintained substantially above the desired finished temperature of the product.

28. A method of heating and cooking food products, comprising the steps:

(a) impinging gases at predetermined high velocity and at a predetermined humidity and elevated temperature substantially above the desired finished temperature of the product against the outer surfaces of a food product;

(b) substantially reducing the velocity of said gases while maintaining the ambient temperature around the food product at approximately the same elevated temperature as in the preceding impingement step for a predetermined period of time to enable equilibration of the temperature gradients within the food product;

(c) following such reduced velocity equilibration time period with another impingement of gases at high velocity and at a predetermined humidity and elevated temperature substantially above the desired finished temperature of the product against the outer surfaces of the food product; and

(d) following such second high velocity impingement step with another reduced velocity equilibration time period at an elevated temperature approximately equal to the elevated temperature of the preceding impingement step to again enable equilibration of temperature gradients within the food product, whereby the reduced velocity equilibration steps are alternated with said high velocity impingement steps to effectively isolate such high velocity impingements from one another and to enable efficient and relatively rapid, pulse-type cooking of the food product at temperatures substantially

above the desired finished temperature of the product.

29. The method of claim 28, further comprising a first step of tempering the food product prior to the first high velocity impingement step by subjecting the food product to relatively low velocity gases having a temperature approximately equal to the predetermined elevated temperature of the first succeeding impingement step.

30. The method of claim 28, wherein the gases impinged upon the food product during separate high velocity impingement steps are impinged at different velocities to vary and control the amount of thermal energy applied to the product during each such impingement step.

31. The method of claim 28, wherein the gases impinged upon the food product during separate high velocity impingement steps are impinged at different temperatures to vary and control the amount of thermal energy applied to the product during each such impingement step.

32. The method of claim 28, wherein the gases impinged upon the food product during separate high velocity impingement steps are impinged at different humidities to vary and control the amount of thermal energy applied to the product during each such impingement step.

33. The method of claim 28, wherein the method is completed in a continuous manner within an apparatus having a plurality of connected zones corresponding to the alternating high velocity impingement and reduced

velocity equilibration steps hereof.

34. The method of claim 33, wherein at least some of the gases from adjacent high velocity impingement zones of the continuous apparatus are recirculated within the apparatus through the interposed low velocity equilibration zones.

35. The method of claim 28, further comprising the additional step of augmenting the heating and cooking of the food product with microwave energy during one or more of the steps.

36. The method of claim 28, wherein each high velocity impingement step is both preceded and followed by a step of subjecting the food product to lower velocity gases at elevated temperature substantially above the desired finished temperature of the product.

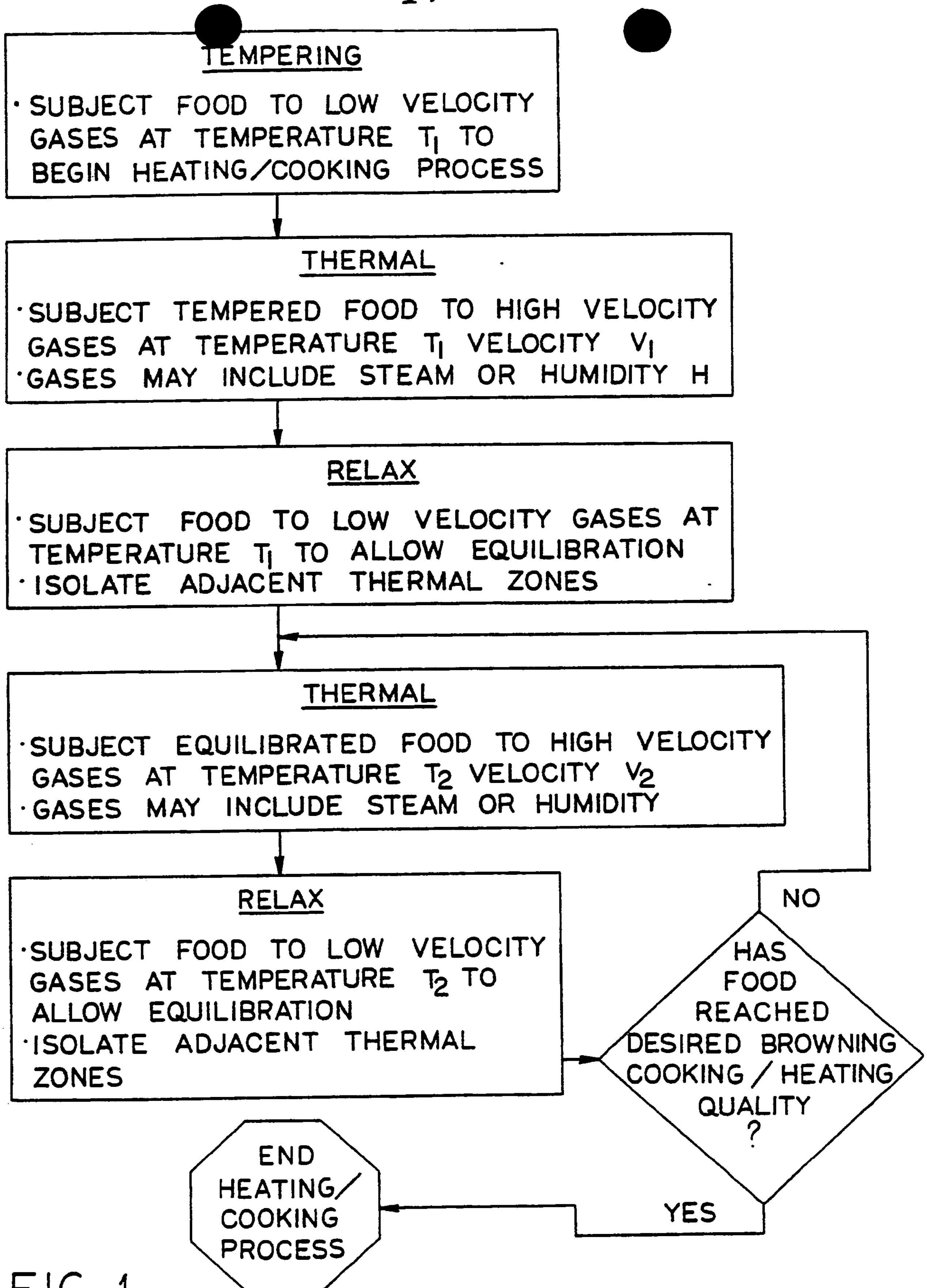

TEMPERING
· SUBJECT FOOD TO LOW VELOCITY GASES AT TEMPERATURE $T_1$ TO BEGIN HEATING/COOKING PROCESS
THERMAL
· SUBJECT TEMPERED FOOD TO HIGH VELOCITY GASES AT TEMPERATURE $T_1$ VELOCITY $V_1$
· GASES MAY INCLUDE STEAM OR HUMIDITY H
RELAX
· SUBJECT FOOD TO LOW VELOCITY GASES AT TEMPERATURE $T_1$ TO ALLOW EQUILIBRATION
· ISOLATE ADJACENT THERMAL ZONES
THERMAL
· SUBJECT EQUILIBRATED FOOD TO HIGH VELOCITY GASES AT TEMPERATURE $T_2$ VELOCITY $V_2$
· GASES MAY INCLUDE STEAM OR HUMIDITY
RELAX
· SUBJECT FOOD TO LOW VELOCITY GASES AT TEMPERATURE $T_2$ TO ALLOW EQUILIBRATION
· ISOLATE ADJACENT THERMAL ZONES
HAS FOOD REACHED DESIRED BROWNING COOKING / HEATING QUALITY ?
NO
YES
END HEATING/ COOKING PROCESS

FIG. 1

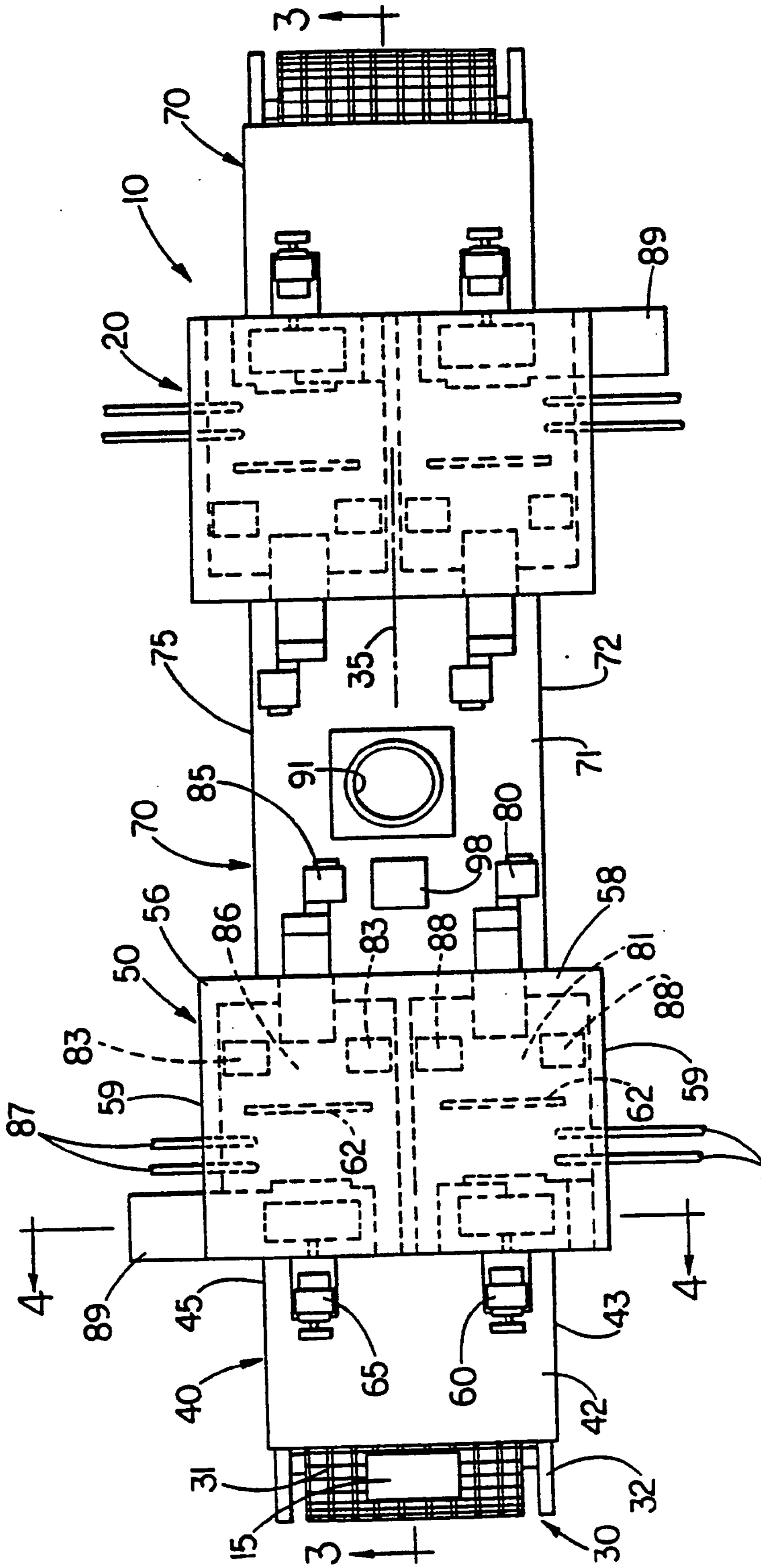
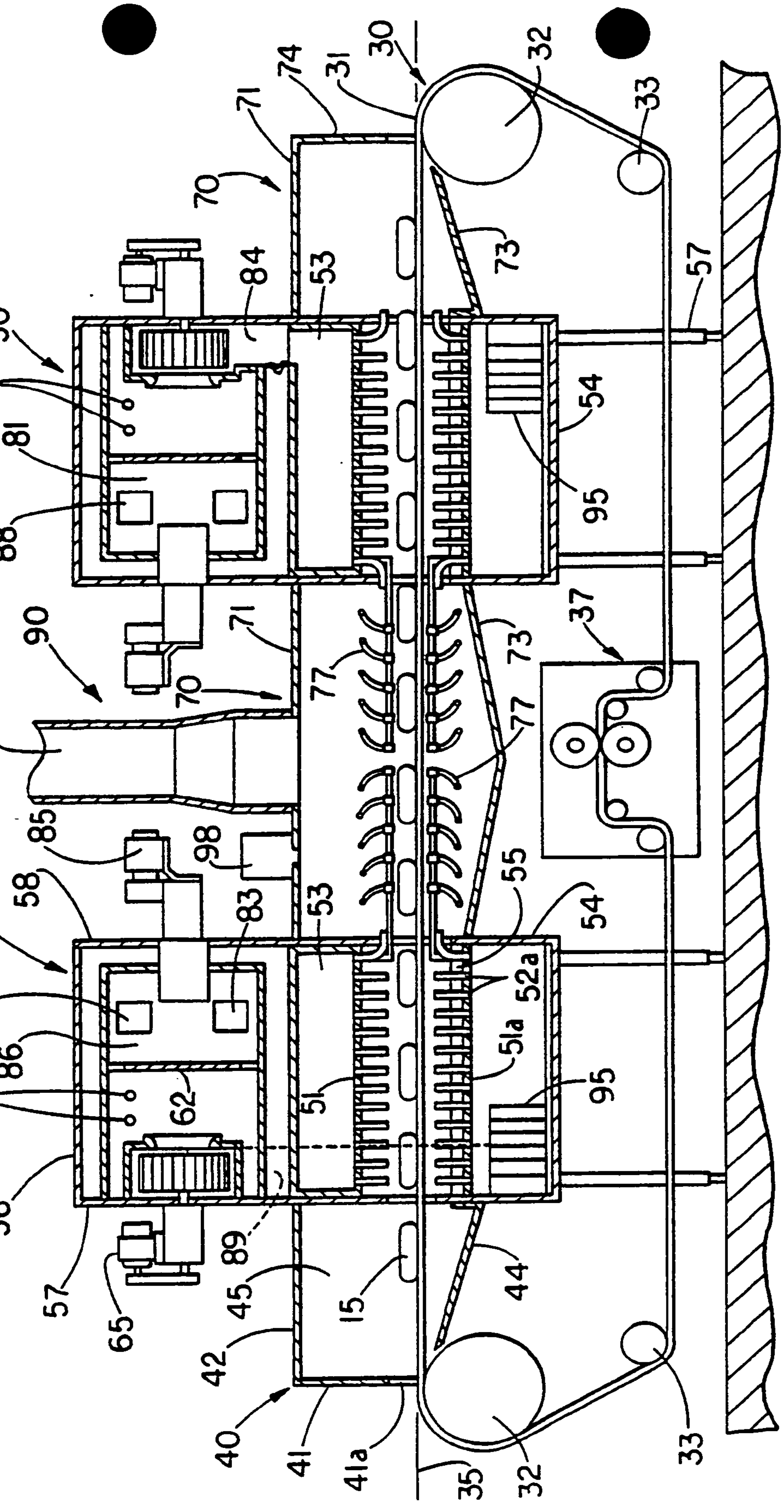

3
70
10
89
20
35
75
72
91
71
85
70
80
98
58
56
86
83
88
81
50
88
83
59
59
62
87
62
82
89
4
45
43
4
65
60
40
42
31
32
15
30
3

FIG. 2



30
31
32
33
74
71
70
73
57
84
53
50
82
81
88
54
95
37
90
91
77
85
98
58
83
86
87
62
51
51a
52a
55
56
65
89
45
15
44
42
40
41
41a
35


FIG. 3

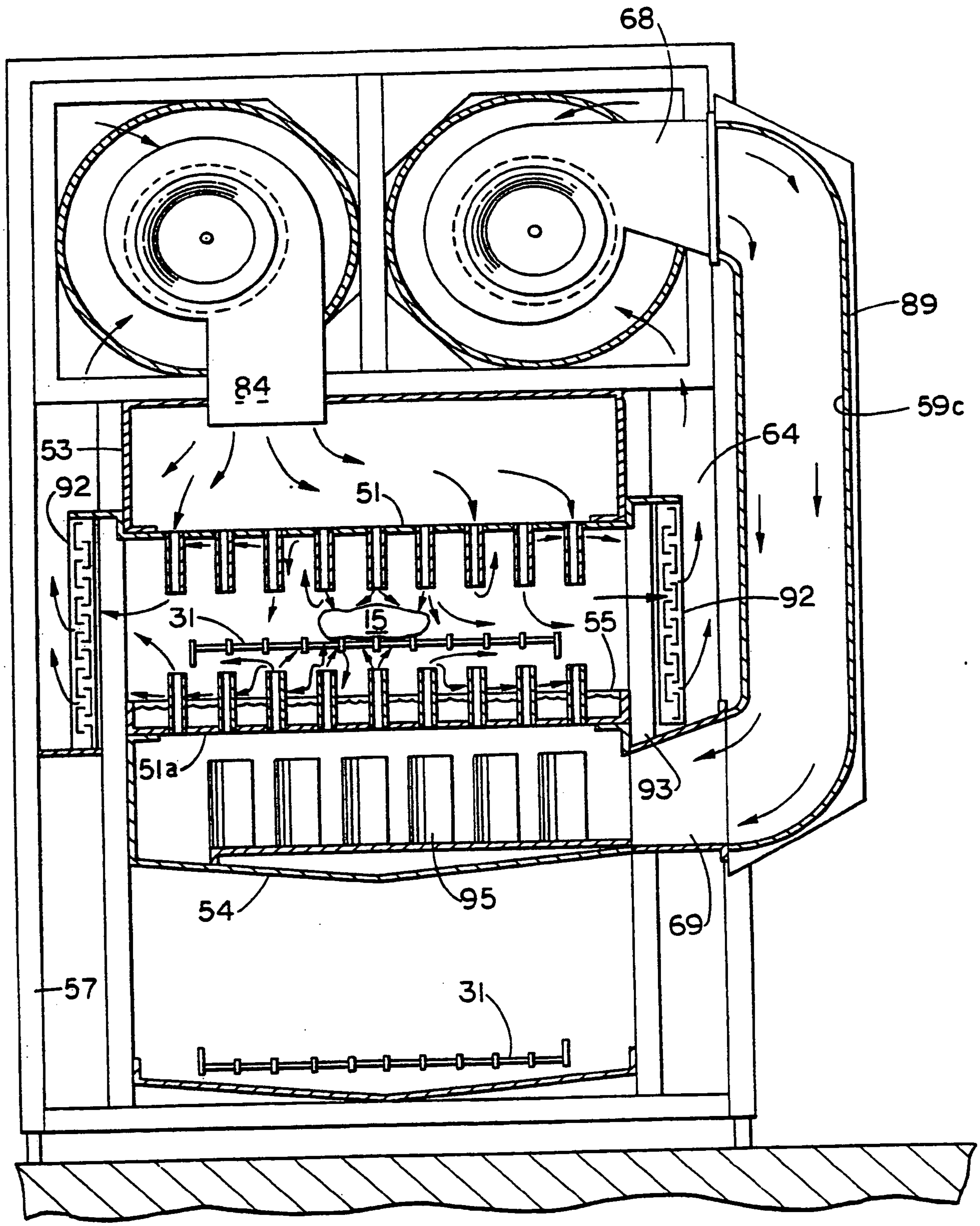



FIG. 4

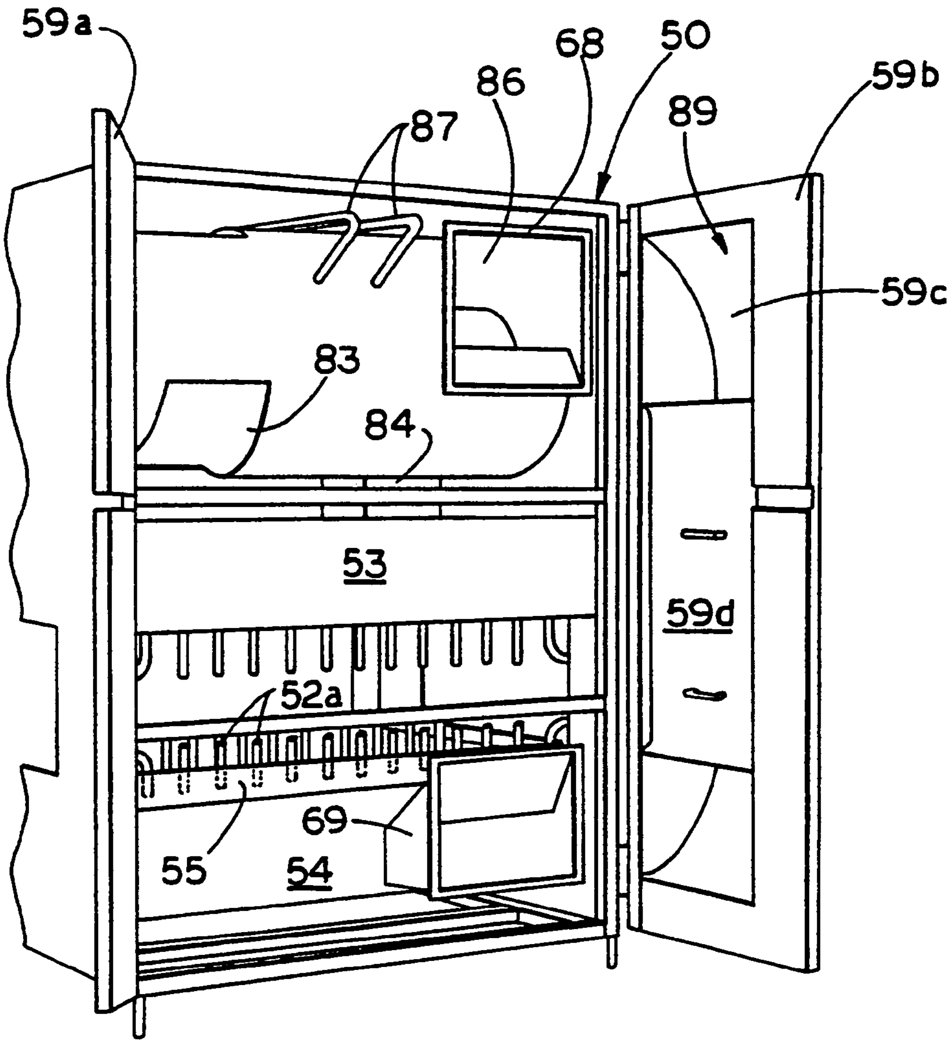



FIG. 5

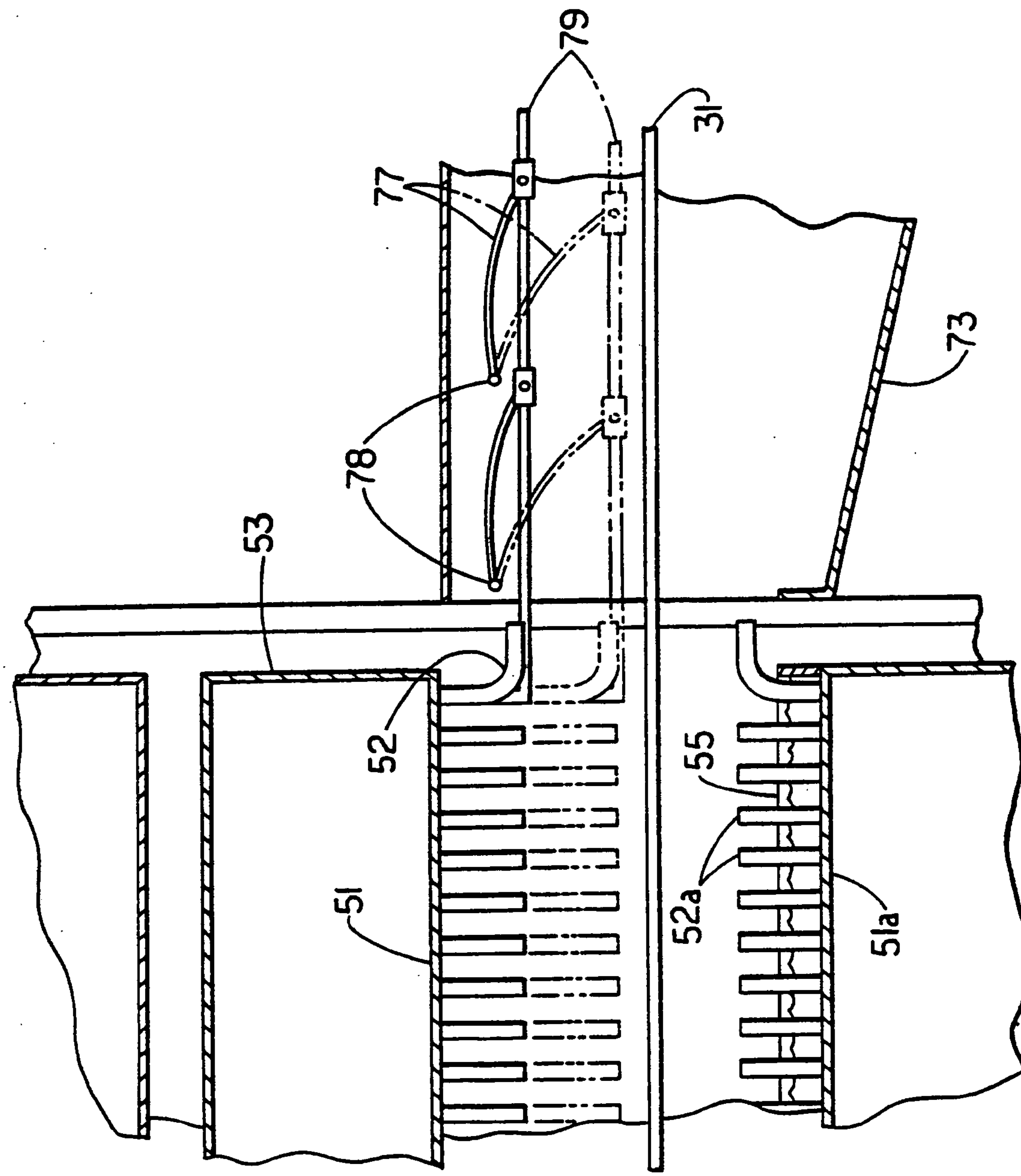



FIG. 6

International Application No PCT/US 88/01485

**I. CLASSIFICATION OF SUBJECT MATTER** (if several classification symbols apply, indicate all) [6]

According to International Patent Classification (IPC) or to both National Classification and IPC

$IPC^4$: A 47 J 39/00; A 23 L 1/01

**II. FIELDS SEARCHED**

Minimum Documentation Searched [7]

| Classification System | Classification Symbols |
|---|---|
| $IPC^4$ | A 47 J; F 24 C; A 23 L |

Documentation Searched other than Minimum Documentation to the Extent that such Documents are Included in the Fields Searched [8]

**III. DOCUMENTS CONSIDERED TO BE RELEVANT** [9]

| Category [*] | Citation of Document, [11] with indication, where appropriate, of the relevant passages [12] | Relevant to Claim No. [13] |
|---|---|---|
| X | EP, A, 0086568 (PATENTSMITH INC.) 24 August 1983 see the whole document | 1-5,8,9, 12-15,18, 19,22,24, 25,27-31, 33 |
| A | EP, A, 0226350 (LINCOLN FOODSERVICE PRODUCT INC.) 24 June 1987 see the whole document | 1 |
| A | US, A, 4409453 (SMITH) 11 October 1983 see the whole document cited in the application | 1,6 |

* Special categories of cited documents: [10]
- "A" document defining the general state of the art which is not considered to be of particular relevance
- "E" earlier document but published on or after the international filing date
- "L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
- "O" document referring to an oral disclosure, use, exhibition or other means
- "P" document published prior to the international filing date but later than the priority date claimed
- "T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
- "X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step
- "Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.
- "&" document member of the same patent family

**IV. CERTIFICATION**

| Date of the Actual Completion of the International Search | Date of Mailing of this International Search Report |
|---|---|
| 18th August 1988 | 19. 09. 88 |
| **International Searching Authority** | **Signature of Authorized Officer** |
| EUROPEAN PATENT OFFICE | P.C.G. VAN DER PUTTEN |

## ANNEX TO THE INTERNATIONAL SEARCH REPORT ON INTERNATIONAL PATENT APPLICATION NO. US 8801485

SA 22263

This annex lists the patent family members relating to the patent documents cited in the above-mentioned international search report.
The members are as contained in the European Patent Office EDP file on 12/09/88
The European Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

| Patent document cited in search report | Publication date | Patent family member(s) | Publication date |
|---|---|---|---|
| EP-A- 0086568 | 24-08-83 | AU-A- 1064883 | 28-07-83 |
| | | JP-A- 58180120 | 21-10-83 |
| | | US-A- 4474498 | 02-10-84 |
| | | US-A- 4479776 | 30-10-84 |
| | | CA-A- 1192075 | 20-08-85 |
| | | AU-B- 560630 | 09-04-87 |
| EP-A- 0226350 | 24-06-87 | AU-A- 6618586 | 11-06-87 |
| | | JP-A- 62138150 | 20-06-87 |
| | | US-A- 4701340 | 20-10-87 |
| US-A- 4409453 | 11-10-83 | US-A- 4479776 | 30-10-84 |
| | | US-A- 4154861 | 15-05-79 |
| | | US-A- 4289792 | 15-09-81 |
| | | US-A- 4338911 | 13-07-82 |
| | | US-A- 4492839 | 08-01-85 |

EPO FORM P0479

For more details about this annex : see Official Journal of the European Patent Office, No. 12/82